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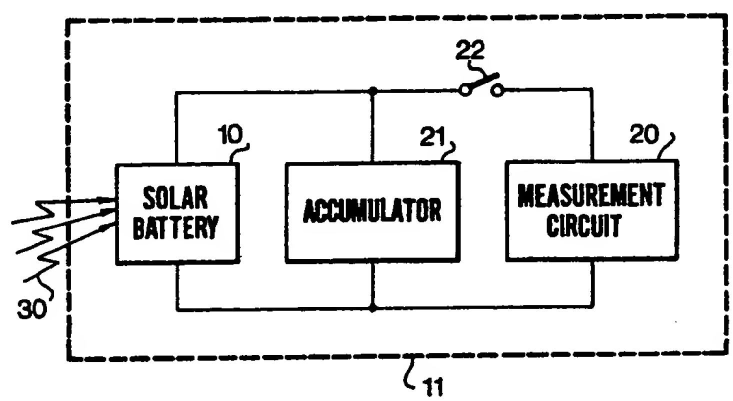
(54) **Electronic clinical thermometer**

(57) An electronic clinical thermometer including a circuit 20 for measuring and displaying temperature sensed by a sensor and accumulating means 21 for supplying electric power to the circuit, has a solar cell 10 connected to the accumulating means, and the circuit, accumulating means and solar cell are housed in a liquid-tight light-permeable envelope. The accumulating means comprises a supercapacitor or a secondary battery. A switch 22 to conserve electrical energy when the thermometer is not being used comprises either a magnetic reed switch which is opened by proximity to a magnet provided in a thermometer carrying case, or a temperature sensitive reed switch which closes in response to heat from the body being measured.

FIG. 8



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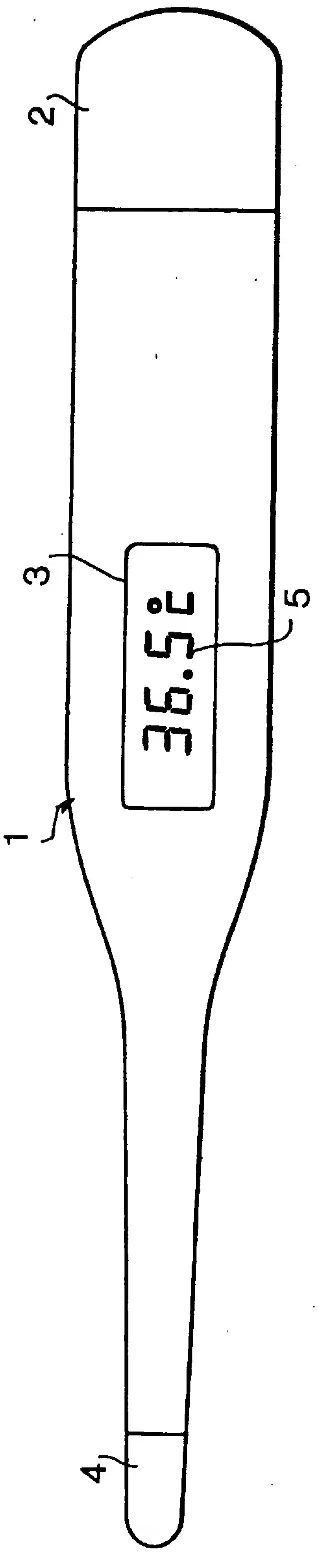


FIG. 1

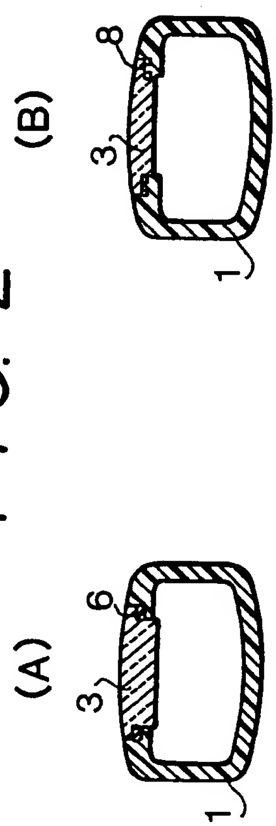


FIG. 2

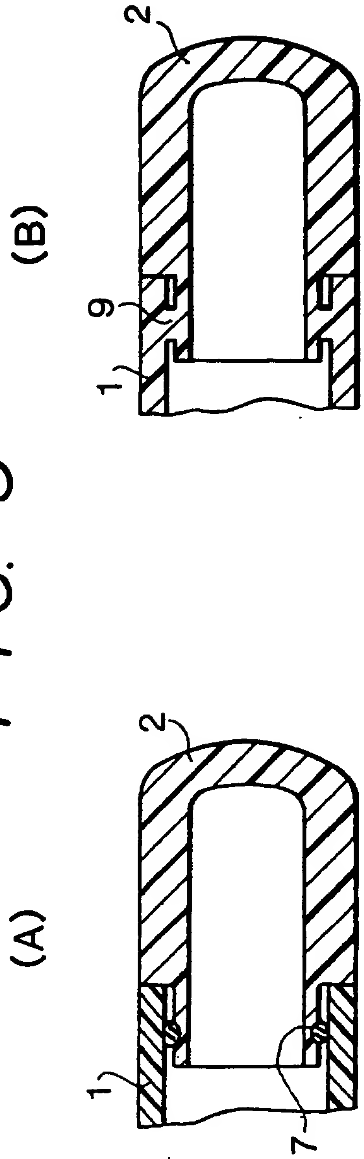


FIG. 3

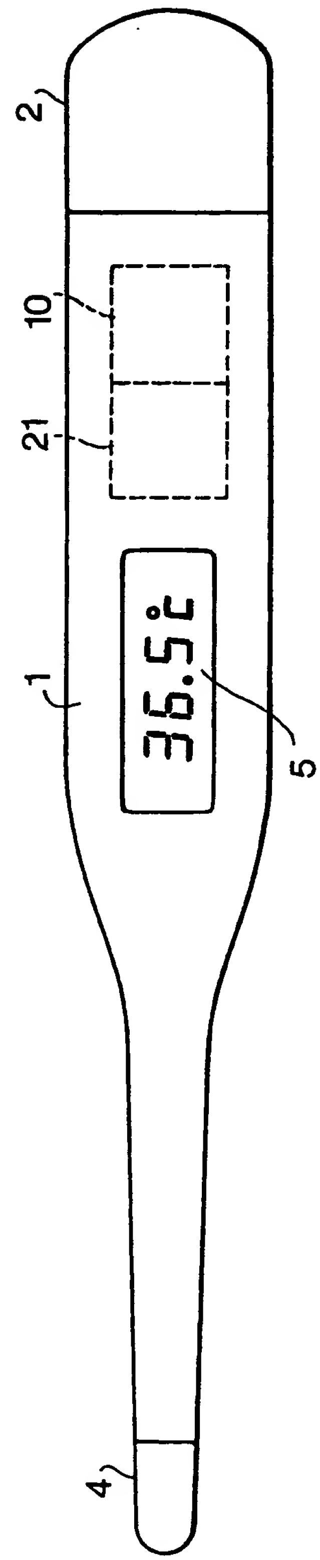


FIG. 4

FIG. 5

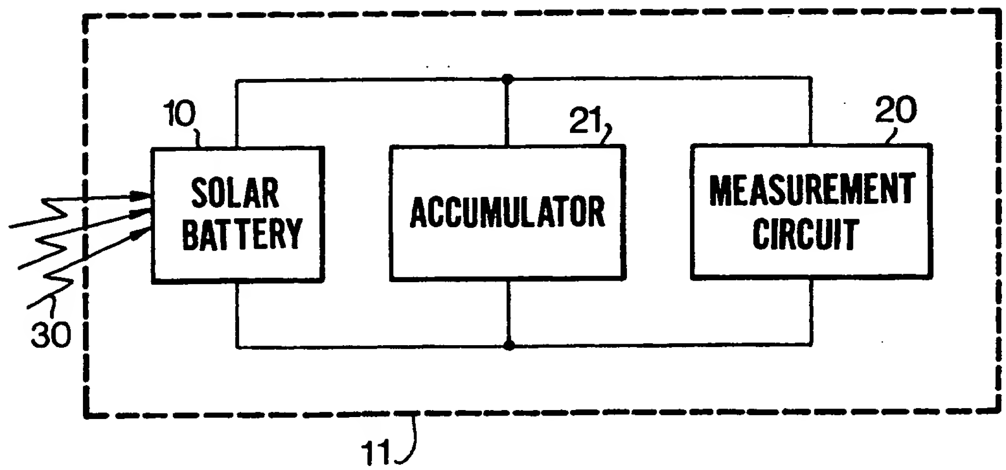


FIG. 6

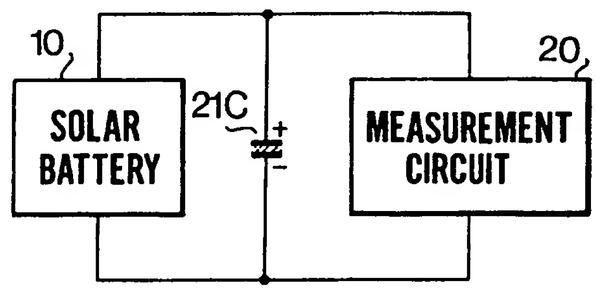


FIG. 7

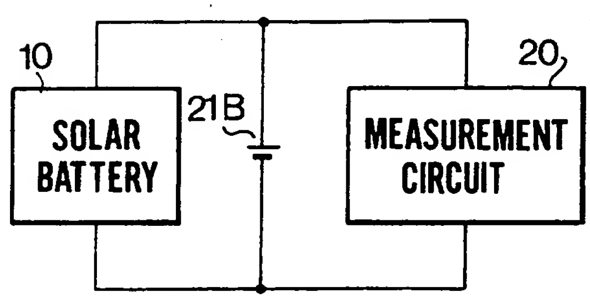


FIG. 8

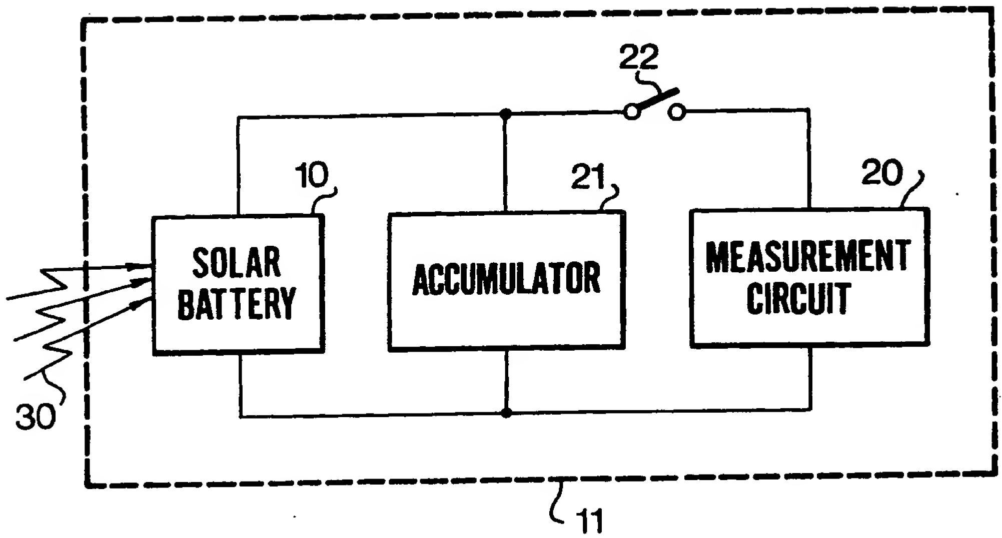
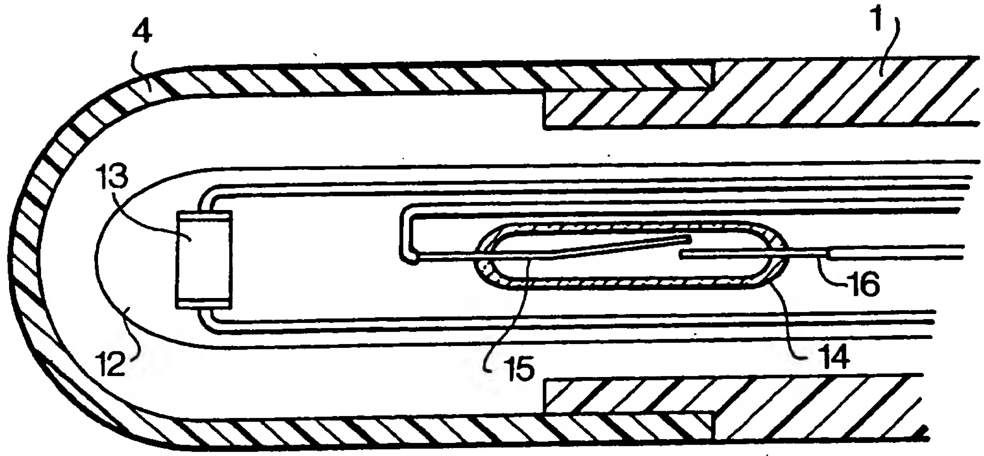

22
10
21
20
SOLAR BATTERY
ACCUMULATOR
MEASUREMENT CIRCUIT
30
11

FIG. 9


4
1
13
16
12
15
14

SPECIFICATION

Electronic clinical thermometer

This invention relates to an electronic clinical thermometer, particularly an electronic clinical thermometer having a waterproof construction and incorporating power supply means.

An electronic clinical thermometer generally comprises an envelope accommodating a temperature-dependent element such as a thermistor, an arithmetic display unit and a battery. The arithmetic display unit is constituted by, e.g., large-scale integrated (LSI) circuitry and is adapted to sense a temperature-induced change in the resistance of the temperature-dependent element as a change in pulse oscillation frequency, convert the oscillation frequency into a temperature reading expressed in, say, centrigrade or Fahrenheit upon correcting the non-linearity of the temperature-dependent element, and displaying the temperature on a display device.

Electronic clinical thermometers employed in hospitals or clinics are put into use quite often and therefore rely upon a secondary battery or the like as the power supply for the arithmetic display unit. In the prior art, several methods are available for charging the secondary battery. According to one of these methods, the secondary battery is removed from the envelope of the thermometer and is then charged by a separate charging unit. This expedient is inconvenient, however, in view of the labor involved in the repeated and frequent charging of the large numbers of thermometers that would be used in a hospital or the like. Another drawback is that the thermometer envelope cannot be provided with a perfect liquid-tight seal because of the need to remove the secondary battery for charging. Consequently, an electronic clinical thermometer of this type does not readily withstand sterilization and cleansing in water or a reagent such as chlorohexizine gluconate when used in an institution such as a hospital or clinic.

Another method relies upon a connector for connecting the charging unit to the electronic clinical thermometer in order to charge the secondary battery. Though this method does not require removal of the secondary battery, it does lead to problems such as poor connector contact. In addition, considerable labor is involved in connecting the charging unit to a number of the thermometers one at a time. In hospitals where large numbers of thermometers are used at the same time, charging the thermometers simultaneously has proven to be extremely difficult.

Another arrangment, which is limited to electronic clinical thermometers of large size, has the charging unit housed within the thermometer proper, with charging being accomplished by connecting the charging unit to a commercial power supply. However, the overall apparatus is not only large in size but also requires that a connector be provided for each and every thermomemter to effect the connection to the commerical power supply. This results in the likelihood of such problems as poor contact, as mentioned above, and involves handling difficulties when cleaning or sterilizing the thermometer.

Still another available method uses an arrangement having two physically separate coils one of which is provided at the base end of the electronic clinical thermometer, the other of which is provided on the top surface of the charging unit. The thermometer, which has a generally rectangular configuration, is set at a prescribed position on the top surface of the charging unit, and the two coils are coupled electromagnetically to charge the secondary battery of the thermometer. However, even this method does not allow a plurality of electronic clinical thermometers to be charged simultaneously because an efficient charging operation cannot be performed unless the charging unit coil and each thermometer coil are brought into a favorably coupled state by accurately positioning the thermometer coil relative to the charging unit coil in a one-on-one relationship. If the system were to be arranged to charge a plurality of the thermometers, then the charging unit would need a number of coils equal to the number of thermometers being charged. This would not only make the charging unit too large for practical use but would also be wasteful of energy in instances where the number of thermometers requiring charging is less than the number of charging unit coils.

So long as the electronic clinical thermometer is of the above-described type, efficient charging of the secondary battery housed by the thermometer will be difficult regardless of whichever of the foregoing charging methods is employed. Accordingly, the advantage of using the secondary battery, namely the fact that the battery does not require the labor of replacement, is largely offset in hospitals or clinics where large numbers of the thermometers are used simultaneously. Moreover, regardless of the method adopted, a commercial power supply must be relied upon in some fashion to perform the charging operation.

According to the present invention there is provided an electronic clinical thermometer comprising circuitry for measuring temperature sensed at a region of interest, and for displaying the temperature measured, accumulating means for supplying electronic power to the circuitry, a solar cell connected to the accumulating means and having a light-receiving surface, and a liquid-tight envelope which has a hollow interior housing the circuitry, accumulating means and solar cell and which can admit light to the light-receiving

surface of the solar cell.

In a preferred embodiment of the present invention, the accumulating means comprises a secondary battery or a supercapacitor. The envelope can have a light-permeable portion or window at least at a part thereof facing the light-receiving surface of the solar cell.

In another embodiment of the present invention, the envelope comprises a main case and at least one cap fitted together liquid-tightly, e.g. by fusing or solvent-welding, with the main case housing the circuitry, accumulating means and solar cell. Preferably at least most (e.g. the said main case) is of light-transmitting material; the latter may be rendered opaque over part of its surface, leaving a display window and a portion for transmitting light to the receiving surface of the solar cell.

Embodiments of the present invention are described below, by way of example only, in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts and in which:

Figure 1 is a side view showing the external appearance of an embodiment of an electronic clinical thermometer according to the present invention;

Figures 2A and 2B are cross-sectional views showing different constructions of a display window of an electronic clinical thermometer embodying the present invention;

Figures 3A and 3B are cross-sectional views showing different constructions of a case and cap constituting an electronic clinical thermometer embodying the present invention, the case accommodating the main functional units of the thermometer;

Figure 4 is a block diagram showing the overall construction of an electronic clinical thermometer incorporating a solar cell in accordance with an embodiment of the present invention;

Figure 5 is a block diagram of a circuit layout for the electronic clinical thermometer of the illustrated embodiment;

Figures 6 and 7 are block diagrams showing circuit arrangements using a supercapacitor and secondary battery, respectively, as an accumulator;

Figure 8 is a block diagram of the circuit lay-out of Fig. 5 equipped with a switch; and

Figure 9 is an enlarged cross-sectional view of an electronic clinical thermometer of the Fig. 8 type in which a temperature-sensitive reed switch is used as the switch.

Fig. 1 is a view showing the external appearance of a electronic clinical thermometer according to the present invention. The thermometer includes a main case 1 which defines a hollow rod for accommodating the main functional components of the thermometer, and which is made of plastics such as polycarbonate or acrylic resin, the main case 1 being somewhat larger in size than a so-called flat-type mercury clinical thermometer, a cap 2 for closing the base end of the main case 1 after the main functional components have been introduced into the main case, a transparent display window 3 provided in the main case 1, a cap 4 at the temperature-sensing end of the thermometer, and a body temperature display unit 5 visible within the thermometer through the display window 3. The construction is such that these elements are assembled together so as to maintain a liquid-tight seal.

One example of liquid-tight structure is as shown in Fig. 2A. Here a liquid-tight seal is provided between the main case 1 and display window 3 by fitting the window 3 into the case 1 through the intermediary of an O-ring 6. In another example, as shown in Fig. 2B, the liquid-tight seal is provided by solvent-welding or fusing the display window 3 and main case 1 together at a joint 8.

The main case 1 and end cap 2 may be sealed together liquid-tightly in the manner shown in Fig. 3A or 3B. In Fig. 3A, a portion of the end cap 2 is inserted into the main case 1 from the base end thereof, and the two are fitted together via an O-ring 7. In Fig. 3B, the end cap 2 and main case 1 are sealed together by solvent-welding or fusing at a joint 9.

Other methods are possible, though not illustrated. For example, a liquid-tight seal can be achieved through simple adhesion, or by forming at least the contacting portion of the main case 1 or cap 2 of a soft body such as a rubber or elastomer.

In the structure shown in Fig. 3, the cap 2 is shown inserted into the main case 1. The converse arrangement may also be adopted, however, namely one in which the main case is inserted into the cap. Though not shown, a liquid-tight seal is maintained between the cap 4 and the main case 1 by fitting them snugly together unassisted or with the aid of a bonding agent.

As shown in Fig. 4, a display window is constituted by a portion of the main case 1, which is transparent. This facilitates the provision of the display window. Disposed within the transparent main case 1, which is composed of e.g. polycarbonate or acrylic resin, is a solar cell 10 serving as an internal power supply. The solar cell 10 is disposed at a position where it may intercept ambient light that has passed through the transparent case 1. With the exception of the temperature display unit 5, solar cell 10 and an accumulator 21, described below, the other internal components of the thermometer are not shown. Portions of the thermometer which need not be transparent can be made opaque by subjecting the inner or outer surface of the main case 1 to a non-transparent screen printing process or the like where desired.

As to the structure within the main case 1

of the electronic clinical thermometer shown in Fig. 4, a temperature-dependent element such as a thermistor is disposed in the cap 4 at the tip of the main case 1. Sealed liquid-tightly within the main case 1 are the display unit 5 which, owing to the incorporation of a large-scale integrated circuit (LSI), serves also as an arithmetic unit, the abovementioned accumulator 21 comprising a rechargeable secondary battery or supercapacitor (a small-size, high-capacity capacitor developed by recent advances in ultra-thin plastics film techniques), and the abovementioned solar cell 10. In operation, a temperature-induced change in the resistance of the temperature-dependent element is converted into a change in frequency, the arithmetic display unit 5 measures the frequency to calculate the temperature corresponding thereto, and the display unit provides a visual read-out of the temperature in centigrade or Fahrenheit. The arithmetic display unit 5 for performing the temperature measurement and display functions employs well-known circuitry disclosed in the specification of British Patent Application No. 2113397 laid open on August 3, 1983.

A block diagram of a circuit lay-out for the thermometer of Fig. 4 is illustrated in Fig. 5. The thermometer has a circuit lay-out 11 indicated by the dashed line in Fig. 5; this includes a body temperature measurement circuit 20 comprising a temperature-dependent element and an arithmetic display unit, the accumulator 21, and the solar cell 10. The solar cell 10 receives ambient light 30 to produce the electrical energy need to operate the measurement circuit 20, with the energy being stored in the accumulator 21.

Examples of the accumulator 21 are shown in Figs. 6 and 7, the former employing a supercapacitor as the accumulator 21, the latter employing a secondary battery. The circuit connections are the same in either case.

As shown in Fig. 8, a switching unit 22 may be provided between the accumulator 21 and body temperature measurement circuit 20. With this arrangement, electrical energy is conserved by opening the switching unit to suppress power consumption when the thermometer is not being used.

An embodiment of the switching unit 22 is illustrated in Fig. 9. As shown, a temperature-sensitive reed switch 14, which is provided in the vicinity of the temperature-dependent portion of the electronic clinical thermometer, serves as the switching unit 22, the latter constituting the main power supply switch of the thermometer. The reed switch 14 is affixed to a printed circuit board 12, which also serves to mount a temperature-dependent element 13, such as a thermistor, for sensing body temperature. In response to heat which is transmitted through the cap 4 from the outside, the temperature-sensitive reed switch 15 (which may comprise a bimetal or shape-memorizing alloy) undergoes deformation, thereby coming into contact with a fixed lead 16 to close the contacts of the switch. This supplies power to the temperature measurement circuit 20 so that a temperature measurement may start.

In place of the temperature-sensitive reed switch, use can be made of, e.g., a magnetically sensitive reed switch in cooperation with a magnet provided within a case for carrying the thermometer. Whenever the thermometer is taken out of the case as when temperature is to be measured, the reed switch closes owing to its removal from the magnetic field produced by the magnet remaining behind in the case. Thus, power is supplied to the temperature measurement circuit 20 automatically merely by extracting the thermometer from its case.

In an electronic clinical thermometer of the present invention, a liquid-tight seal can be adopted regardless of whether the thermometer is of the type in which electrical energy is supplied to and used to charge the internal accumulator without contact with the outside, or of the type in which an internal power supply switch is opened and closed without contact with the outside. Accordingly, the internal functioning of the thermometer is protected against humidity and moisture; internal electrode contacts, electronic components and soldered joints are improved in reliability and prolonged in life, and malfunctions due to leakage into the wiring patterns are prevented, as are battery discharge and corrosion due to leakage. The end result is an electronic clinical thermometer of enhanced reliability and longer life.

In accordance with an electronic clinical thermometer of the present invention as described and illustrated above, both an accumulator and a solar cell serving as a power supply for supply the accumulator with power are incorporated within the main case or envelope of the thermometer. It is therefore possible to dispense with an opening for battery replacement and a connector for charging. The thermometer envelope can therefore be provided with a reliable liquid-tight seal to protect the interior of the thermometer. Thus, the invention affords an electronic clinical thermometer of good durability.

Furthermore, by forming the overall envelope of a transparent material, it is unnecessary to construct the display window and the portion through which light impinges upon the solar cell of components separate from the envelope. As a result, a specially designed liquid-tight structure is not required at these portions of the envelope, thereby enhancing liquid-tight reliability and lowering cost.

Providing the envelope with a liquid-tight seal in the above manner improves durability with respect to cleaning and sterilization. Also,

very little labor is required to charge the thermometer, it sufficing to place the thermometer in a bright location with the portion of the envelope through which light passes to the solar cell being exposed.

In addition, by using a supercapacitor as the accumulator, the thermometer can be used over a wider range of temperatures than that possible with a battery. There is less deterioration than that experienced with a second battery and charging is simpler. Rapid charging immediately before use is also possible.

Many apparently widely different embodiments of the present invention can be made without departing from the invention, which is not limited to the specific embodiments described above.

CLAIMS

1. An electronc clinical thermometer comprising circuitry for measuring temperature sensed at a region of interest, and for displaying the temperature measured; accumulating means for supplying electric power to the circuitry; a solar cell connected to the accumulating means and having a light-receiving surface; and a liquid-tight envelope which has a hollow interior housing the circuitry, accumulating means and solar cell and can admit light to the light-receiving surface of the solar cell.

2. A thermometer according to claim 1 wherein the accumulating means comprises a secondary battery.

3. A thermometer according to claim 1 wherein the accumulating means comprises a supercapacitor.

4. A thermometer according to claim 1, 2 or 3 wherein the envelope has a light-permeable portion at least at a part thereof facing the light-receiving surface of said solar cell.

5. A thermometer according to any preceding claim wherein the envelope comprises a main case and at least one cap fitted together liquid-tightly, the main case housing the circuitry, accumulating means and solar cell.

6. A thermometer according to any of claims 1 to 4 wherein at least most of the envelope is of light-transmitting material.

7. A thermometer according to claim 5 wherein at least the main case is of light-transmitting material.

8. A thermometer according to claim 6 or 7 wherein the envelope or main case is rendered opaque over part of its surface, leaving a display window and a portion for transmission of light to the light-receiving surface of the solar cell.

9. A thermometer according to any preceding claim wherein the circuitry includes an on/off switch which is normally off and is switched on when the thermometer is to be used.

10. A thermometer according to claim 9 wherein the switch is heat sensitive or operated by removal of the thermometer from a storage case.

11. An electronic clinical thermometer substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

12. An electronic clinical thermometer substantially as hereinbefore described with reference to Fig. 1 together with any of Figs. 2A, 2B, 3A and 3B of the accompanying drawings.

13. An electronic clinical thermometer substantially as hereinbefore described with reference to Fig. 4 of the accompanying drawings.

14. An electronic clinical thermometer substantially as hereinbefore described with reference to Fig. 4 together with any of Figs. 5 to 9 of the accompanying drawings.

15. An electronic clinical thermometer according to claim 1 wherein the circuitry, accumulating means and solar cell are substantially as hereinbefore described with reference to any one of Figs. 5 to 8 of the accompanying drawings.

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closed through heat treatment or some like technique at the terminal end of stem portion 5.

In another form of the invention, improved thermometer 1 may also include a stress riser which is formed on a portion of thermometer stem 5 which is generally external to the body cavity when improved thermometer 1 is in use. Such a stress riser may be in the form of a notched area 53 shown in FIG. 6, passing around the periphery of the stem portion 5 of thermometer 1 in the neighborhood of tubular element end 32. Thus, with a stress riser present and thermometer 1 being inserted into a body cavity, a resultant stress load sufficient to break thermometer 1, would cause cracking or breakage in a section which would not be detrimental to the health of the user.

In order to provide a smooth or more planar interface area 31 where layers 2 and 3 are joined, layer or stem cover 3 may be tapered at the joining end section. This would have the effect of producing a more continuous contour interface area 31. In another embodiment, layer or cover 3 may be provided with a reduced outer diameter area in the section near interface area 31. Bulb cover 2 may then be fitted over the reduced outer diameter area of layer 3 and bonded thereto by a molding process or some like securing technique.

Referring now to FIGS. 5–8, there is shown various methods of producing improved thermometer 1. In overall concept, thermally conductive second layer 2 is formed over bulb portion 6 of improved thermometer 1. Stem portion 5 is enclosed within substantially transparent first layer or stem cover 3 with the first and second layers 3 and 2 being joined to form an enclosure for improved thermometer 1.

FIG. 5 shows the step of forming thermally conductive or second layer 2 by coating bulb portion 6 of improved thermometer 1 with a thermally conductive material as has hereinbefore been described. Bulb mold material 11 which may be a plastic material impregnated with a high thermal conductivity powder or a high thermal conductivity silicone rubber is initially placed in bulb mold cavity 10 of bulb mold 9. Generally, bulb mold material 11 is maintained in a substantially liquid state priorto the insertion of bulb portion 6 of improved thermometer 1. Bulb portion 6 is generally maintained within bulb mold material or second layer material for a predetermined time until the material is in a substantially hardened state and adheres to bulb portion 6. Coated bulb portion 6 is then withdrawn from bulb mold cavity 10 to provide bulb portion 6 with bulb cover or second layer 2.

In another form of the invention, the step of molding may include the step of providing a gelatin mold having a predetermined contour cavity somewhat similar to bulb mold cavity 10 shown in FIG. 5. In this form, bulb portion 6 is inserted into bulb mold material 11 contained within the gelatin mold. As is to be understood, bulb portion 6 is maintained in the gelatin mold until the mold material 11 adheres to the bulb portion 6 and hardens. Following this step, the gelatin mold outer casing is dissolved. Thus there is provided bulb cover 2 for bulb portion 6 as has hereinbefore been described.

In one form of the invention, first layer or stem cover 3 may be applied by a dip molding process as is shown in FIG. 6. In this method, stem portion 5 of improvied thermometer 1 is inserted into dip mold cavity 13 of dip mold 12. Clear plastic molding material 14 has been inserted into dip mold cavity 13 prior to the insertion of stem portion 5. Molding material 14 is displaced within mold cavity 13 to encompass stem portion 5 after insertion of improved thermometer 1 into mold cavity 13. Molding material 14 is allowed to harden prior to the removal of improved thermometer 1 from cavity 13. After insertion of stem portion 5 to the required depth within mold cavity 13, it is seen that the terminal end of stem portion 5 is provided with a larger clearance between the thermometer end and the lower cavity wall than the clearance on the peripheral boundary of stem portion 5. This permits plastic covering 15 at the terminal end of stem portion 5 to have a greater thickness of molding material 14 adhered thereto than is found on the periphery of the stem portion 5 at areas removed from the stem portion terminal end.

FIGS. 7 and 8 provide for another method of providing layer or stem cover 3 on stem portion 5 of improved thermometer 1. The method steps as depicted in FIGS. 7 and 8 relate to an extrusion type of molding process. In this process, rectal thermometer 18 is inserted within two halves of extrusion mold 16 and 17 having provided therein two halves of extrusion cavity mold 24. Rectal thermometer bulb section 19 includes bulb plastic coating 20 which is formed thereon in some like manner to that which has hereinbefore been described. Clear plastic molding material is inserted under pressure through extrusion mold nozzle 23 and fills the clearance between rectal thermometer 18 peripheral boundaries and the internal walls of extrusion cavity 24. Cavity 24 includes a thickened plastic section 22 at the rectal thermometer terminal end to provide for the extended plastic area at the terminal end of rectal thermometer 18.

What is claimed is:

1. A thermometer having a bulb portion and a stem portion comprising:
   a. a first layer member enclosing said stem portion of said thermometer, said first layer having an index of refraction sufficiently high to provide visual interpretation of the positional location of an internally contained heat expandable substance in relation to indicia formed on said stem portion, and,
   b. a second thermally conductive silicone rubber layer member enclosing said bulb portion of said thermometer, said second layer member being separate and distinct from said first layer member, said first and second layers being joined to form closed contour enclosure for said thermometer throughout an extended length of said thermometer, said first and second layer members being secured to said stem and bulb portion and each of the other for providing contiguous contact of said layers with an outer surface of said thermometer throughout said extended length of said thermometer, said first and second layer member being non-removably secured to said outer surface of said thermometer.

2. The thermometer as recited in claim 1 where said first layer is substantially transparent to provide visual inspection of said heat expandable substance in relation to said indicia.

3. The thermometer as recited in claim 2 where said first layer is formed of a substantially transparent plastic material.

4. The thermometer as recited in claim 2 where said substantially transparent first layer includes a thickness within the approximating range of between 5.0 to 20.0 mils.

5. The thermometer as recited in claim 2 where said first layer includes a terminal closed end section for mating with a terminal end of said stem portion when